Fraunhofer Center for Sustainable Energy Systems

THE IMPACT OF INTERNET BROWSERS ON COMPUTER ENERGY CONSUMPTION

FINAL REPORT TO MICROSOFT
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Executive Summary

Although several studies have evaluated the energy consumption of residential computers, they have not considered the impact that Internet browsers have upon computer energy consumption. Internet browsing represents a large fraction of home computer use, so if computer power draw depends significantly on browser selection, this could have an appreciable impact on the unit electricity consumption (UEC) and annual electricity consumption (AEC) of home computers.

To evaluate this, we installed three popular browsers, Google Chrome, Microsoft Internet Explorer, and Mozilla Firefox, on six new notebook and four desktop computers running Windows 8. We then measured the average power draw over one-second intervals for a six-minute period with each of the individual browsers open, for each of the ten most-visited websites in the U.S. In addition, we also measured power draw for both the Flash® and HTML5 versions of an online video, as well as the Fishbowl HTML5 benchmark.

Our measurements show that the Internet browsers tested increased computer power draw by an average of about 7 to 13 percent for notebooks and 3 to 5 percent for desktops, relative to an "idle" baseline (see Table E-1 and E-2). For the top ten U.S. websites tested, average computer power draw increased the most while using the Chrome browser and the least while using the Internet Explorer browser. Variations in power draw among the websites tested were of a similar magnitude as differences in power draw among browsers.

Table E-1: Notebook average power draw measurements summary (W)

	Baseline	Average, Top 10 Websites
Google Chrome	14.7	16.6
Microsoft Internet Explorer	14.7	15.6
Mozilla Firefox	14.7	16.3

Table E-2: Desktop average power draw measurements summary (W)

	Baseline	Average, Top 10 Websites
Google Chrome	37.8	39.7
Microsoft Internet Explorer	37.8	38.8
Mozilla Firefox	37.8	39.3

Testing of two HTML5 websites (one benchmark, one video) and one Flash® video found that both appear to increase power draw significantly more than the top ten websites tested. Most notably, the HTML5 benchmark test condition more than doubled the notebook power draw for all computers and browsers tested, while desktop power draw increased by approximately 50 percent. Computer power draw also increased for the one Flash® and HTML5 website tested, increasing by approximately 50 and

20 percent for notebook and desktops, respectively. For more information, see the Results section (Section 3). Due to the very limited number of test conditions, we cannot draw robust conclusions about differences in power draw among browsers running Flash® and HTML5. We recommend conducting additional testing of a larger set of Flash® and HTML5 websites to draw more robust conclusions about how these technologies impact computer power draw.

Incorporating the test data into models for residential computer UEC and AEC indicates that the browsers tested increased both by an average of approximately 1 to 3 percent relative to an "idle" baseline. The largest uncertainties in these estimates are the power draw impact of Flash® and the quantity of time residential computers spend with browsers open, particularly on web pages running Flash® video.

1 Introduction

Several studies have evaluated the energy consumption of residential computers (Kawamoto et al. 2001, Roth et al. 2002, Nordman and Meier 2004, Roth et al. 2006, Roth et al. 2008, Urban et al. 2011). They have not, however, considered the impact that Internet browsers have upon computer energy consumption. Internet browsing represents a large fraction of home computer activity, so if computer power draw depends significantly on browser selection, this could have an appreciable impact on the unit electricity consumption (UEC) and annual electricity consumption (AEC) of home computers.

One recent study (TÜV Rheinland 2012) tested six desktop and notebooks computers with three different browsers open, all running the Windows 8 operating system. That study measured computer power draw with the different browsers open to the 20 most-visited websites in Germany, an HTML5 video, and an HTML5 benchmark. Overall, they found that the difference in average computer power draw could vary up to 1.7W for the 20 most-visited websites, 1.2W for the HTML5 video, and 11.6W for the HTML5 benchmark.

Given these differences, the Microsoft Corporation commissioned Fraunhofer USA, Center for Sustainable Energy Systems to conduct additional testing to evaluate how three Internet browsers impact computer power draw and energy consumption: Google Chrome, Microsoft Internet Explorer, and Mozilla Firefox.

1.1 Approach

We took the following project approach:

1. Develop a model for residential computer electricity consumption
2. Develop a test procedure to measure the impact of browsers upon computer power draw
3. Execute the tests per the test procedure.
4. Run the model for residential computer electricity consumption
5. Compose a Final Report to Microsoft

1.2 Report Organization

The report has the following organization:

Section 2 describes the browser energy impact model and test procedure followed.

Section 3 presents the test and energy model results.

Section 4 summarizes the main findings of the study.

Appendix A contains the test data.

2 Browser Energy Impact Model and Test Procedure

2.1 Browser Energy Impact Model

We used a bottom-up approach to evaluate the impact of browsers upon residential computer electricity consumption (see Figure 2-1). Specifically, we estimated computer unit electricity consumption (UEC) using estimates for the annual average usage in each power mode (in hours) and multiplying each by the estimated average power draw in that mode (in Watts). The sum of the UEC over all modes equals the total device UEC. To estimate the national impact, i.e., the annual electricity consumption (AEC) for *all* residential computers in the U.S., we multiplied the UEC values developed for different browsers by the installed base. Sections 2.1.2 and 2.1.3 describe how we extended the model to evaluate the impact of Internet browsers upon computer power draw.

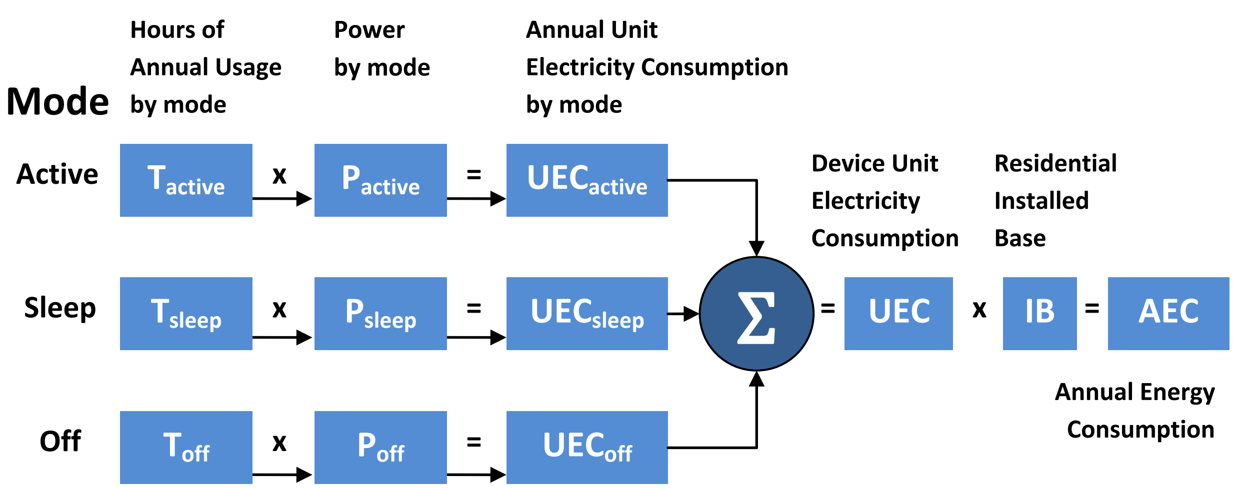

Figure 2-1: Energy consumption impact methodology (from Roth et al. 2002)

For all values, we used the 2010 baseline values for computers from Urban et al. (2011), summarized in Tables 2-1 and 2-2, with the modifications described below.

Table 2-1: Baseline notebook PC electricity consumption characteristics

	Active	Sleep	Off
Power [W]	19	2	1
Usage [hr/yr]	2,915	2,210	2,726
UEC [kWh/yr]	55	4	3

Table 2-2: Baseline desktop computer electricity consumption characteristics

	Active	Sleep	Off
Power [W]	60	4	2
Usage [hr/yr]	3,420	2,150	3,190
UEC [kWh/yr]	205	9	6

2.1.1 Residential Installed Base

Urban et al. (2011) estimates an installed base of 132 million notebook and 101 million desktop computers in the U.S.

2.1.2 Annual Usage by Mode

We estimate the average number of hours that the average notebook and desktop spends in active mode under conditions similar to the different test conditions. Figure 2-2 depicts how we allocate active hours among the different test conditions, while explanations of how we developed the numerical values for each condition follow.

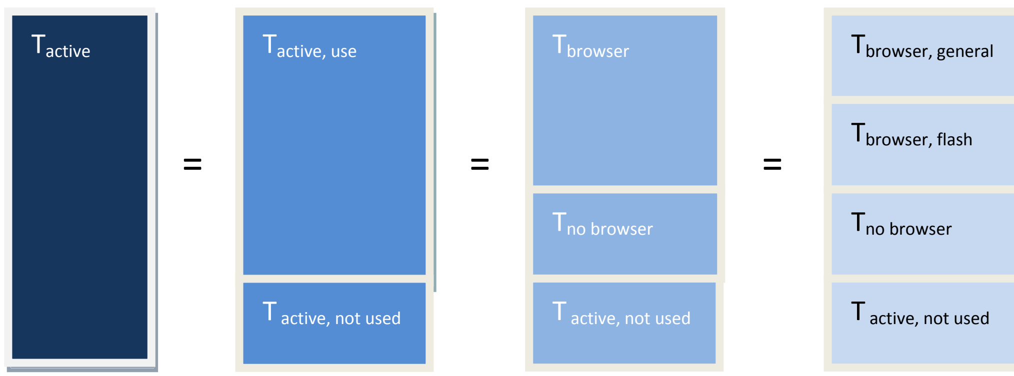

Figure 2-2: Schematic of the browser active-mode time allocation model

T_{active} equals the active usage values in Tables 2-1 and 2-2. It equals the sum of time when a computer actively used, $T_{acitve,use}$, and time when a computer remains on but is not actively being used, $T_{active,not\ used}$. The latter condition includes time when people leave computers on for convenient re-use without the computer entering a low-power mode (i.e., sleep or off). Subsequently, $T_{active,use}$ can be split between time where a browser is open, $T_{browser}$, and time when a browser is not open, $T_{no\ browser}$. Finally, we divide $T_{browser}$ into time when the browser is running Adobe® Flash®, $T_{browser,flash}$, and time when it is not, $T_{browser,\ general}$. We considered including time spent running HTML5 in the model, but decided not to because that period of time appears to be much less than the time spent in Flash®.

We developed estimates for time spent annually in each of these modes, as described below and summarized in Table 2-3.

$T_{active,\ not\ used}$: Based on Urban et al. (2011), desktops and notebook computers spend 46% and 55% of T_{active} in $T_{active,\ use}$, respectively. Thus, the portion of T_{active} that are $T_{active,\ not\ used}$ equal 54% and 45%.

$T_{browser,\ general}$: Estimates for time an average residential *computer* has at least one browser window open could not be found. Instead, we use estimates for time spent online as the basis for time spent with a browser open, as the number of Internet users online (221 million in 2010) is similar to the installed base of computers in homes (233 million in 2010). Such estimates vary appreciable, e.g., comScore (2011) estimates that an average U.S. Internet user spent 32 hours per month online, or just over an hour per day, while eMarketer (2013) sites a market study estimating that an average Internet user spent 3 hours and 7 minutes per day online in 2012, or 95 hours per month. We use 95 hours/month (1,138 hours/year) for this value, acknowledging that this value is likely an upper bound[1] and has appreciable uncertainty.

$T_{browser,\ flash}$: W[3]Tech (2013) estimates that about 18.5% of websites use Flash®. As a check, Google-owned websites account for about 10% of time spent online, a large portion of time spent at Internet domains owned by Google is spent at youtube.com (USA Today 2013), and Adobe® Flash® is the primary program used to view videos. Thus, we assume that 18.5 % of $T_{browser,\ general}$ is spent viewing Flash® content, i.e., 211 hours per year per computer.

Table 2-3: Annual usage by mode summary

Mode	Hours/year		% of Time in Mode	
	Desktop	*Notebook*	*Desktop*	*Notebook*[2]
T_{active}	**3,420**	**2,915**	**39%**	**33%**
$T_{acitve,use}$	1,578	1,590	18%	18%
$T_{active,not\ used}$	1,842	1,325	21%	15%
$T_{browser}$	1,138	1,138	13%	13%
$T_{browser,\ general}$	927	927	11%	11%
$T_{browser,\ flash}$	211	211	2%	2%
$T_{no\ browser}$	441	452	5%	5%
T_{sleep}	**2,150**	**2,210**	**25%**	**25%**
T_{off}	**3,190**	**2,726**	**36%**	**31%**

2.1.3 Power Draw by Mode

In all cases, we use the average desktop and notebook computer power draw values from Urban et al. (2011) as the baseline values, i.e., when the computer is turned on but not using a browser. This best represents the test conditions used to develop the power draw values used in Urban et al. (2011). Consequently, we assign all hours spent in $T_{active,\ not\ used}$, $T_{no\ browser,}$ T_{sleep}, and T_{off} to the power draw values shown in Tables 2-1 and 2-2.

We use the power draw tests for the different browsers and for the Flash® test condition to modify the baseline active-mode power draw values (see Section 2.2). Specifically, for $T_{broswer,\ general}$, we estimate the power draw value by multiplying the Urban et al. (2011) active mode power draw value by the ratio of computer power draw measured while using a given browser to the baseline power measurement, $r_{browser}$, with the *ratio* averaged over all desktop or notebook computers tested. We use the same basic approach for $T_{browser,\ flash}$, multiplying by the ratio of computer power draw measured while using the Flash® test video to the baseline power measurement, $r_{browser,\ flash}$, averaged over all desktop or notebook computers tested.

[1] The value reported appears to include time at both work and home, as well as on all platforms (i.e., tablets and smart phones).

[2] Notebook hours and percentages do not sum to 8,760 and 100% due to an estimated 909 hours spent unplugged per year.

2.2 Power Draw Testing

We purchased ten different computers specified by Microsoft, including four desktops and six notebooks. Table 2-4 summarizes the computers tested and some of their key attributes.

Table 2-4: List and attributes of computers tested

Type	Model	Display	CPU	GPU	Memory	Storage
Notebook	Samsung Series 5	14"	Intel i5	Integrated	4 GB	500 GB
Notebook	Dell Inspiron 17R Special Edition with i7 + 8GB RAM	17.3"	Intel i7	Discrete	8 GB	1,000 GB
Notebook	Toshiba L955-S5370 with 6GB RAM	15.6"	Intel i5	Integrated	6 GB	640 GB
Notebook	ASUS VivoBook X202E	11.6"	Intel i3	Integrated	4 GB	500 GB
Notebook	Lenovo IdeaPad Z585	15.6"	AMD A8	Integrated	6 GB	1,000 GB
Notebook	HP Pavilion G7-2220us Notebook	17.3"	AMD A6	Discrete	4 GB	500 GB
Desktop	HP Envy h8-1450 Desktop: FX-6120 processor, 10GB RAM, 0.5GB AMD Radeon HD7570 Graphics Card		AMD FX	Discrete	10 GB	2,000 GB
Desktop	Dell Inspiron 660s		Intel Celeron 6465	Integrated	4 GB	500 GB
Desktop	HP Envy 20-d030 TouchSmart All-in-one Desktop PC	20”	Intel i3	Integrated	6 GB	1,000 GB
Desktop	Dell XPS 8500 (i7 + discrete 1 GB NVIDIA GeForce GT 640)		Intel i7	Discrete	12GB	2,000 GB

Subsequently, we put each through Test Set-up and Testing procedures described below. In particular, the test procedure is designed to yield meaningful results within the time and scope constraints of the project.

2.2.1 Test Set-Up

During initial testing, we found that a variety of programs pre-installed by the computer manufacturers were resulting in significant fluctuations in computer power draw. Consequently, we removed all pre-installed software from all computers prior to testing and did a “clean” install of the operating system, Windows 8. Subsequently, we installed the most up-to-date versions available of the following programs on each computer:

- The three browsers tested
  - Microsoft Internet Explorer – 10.0.9200.16540, 10.0.9200.16580
  - Google Chrome – 26.0.1410.64
  - Mozilla Firefox – 20.0.1.4847, 21.0.0.4879
- Windows Defender (the built-in Microsoft security software in Windows)
- Adobe Flash® – 11.7.700.169, 11.7.700.202

Subsequently, we disabled all updates for the above programs and Windows alert service throughout the entire test period, as well as other periodic tasks that could cause unwanted changes in power draw. In addition, at the request of Microsoft we set the JavaScript timer frequency to “conserve power” in the Windows power options. We found, however, that the default Javascript time frequency for all computers tested was set to “maximum performance.” We did not investigate the impact of this setting upon browser power draw.

2.2.2 Test Procedure

We followed the following test procedure for all computers, i.e., Units Under Test (UUT), using a Yokogawa WT210 power meter. The power meter was under calibration per ANSI/NCSL Z540-1-1994, and has an accuracy of +/-0.1%. Throughout testing, the room remained between 20 and 22°C.

1. For all notebook computers, ensure that the UUT’s battery is fully charged before beginning testing.
2. Connect the UUT to the Yokogawa WT210 power meter
3. Connect the UUT to the Internet[3]
4. Connect the data acquisition system to the power meter
5. Testing will start a minimum of ten (10) minutes after booting up the PC each time
6. Measure the true root-mean squared (rms) current, power, and voltage for each UUT over a six (6)-minute period at 1Hz (averaging over 1s period) for the following test conditions:
   a) Baseline: No browsers or other windows open
      i) First perform a preliminary measurement of power draw in this mode for the UUT, to ensure that the lowest suitable current range has been selected on the power meter to maximize measurement accuracy
         (1) Record the current range selected for testing the UUT
         (2) Record at least 6 minutes of ‘Baseline’ UUT operation with no browsers.
         (3) Move the mouse/trackpad once a minute to prevent the unit from going idle
   b) Static Website Test: Three different browsers (Internet Explorer, Google Chrome, and Mozilla Firefox) will be used. Each browser will be tested for the Top 10 U.S. websites as of March 25' 2013 (listed below, from Alexa 2013). The UUT will then be rebooted after all ten websites have been tested. In all cases, the browser will have two ‘background tabs’ open to cse.fraunhofer.org and cfvsolar.com, both static landing pages.
      i) Each browser will be directed to the following websites, with all cookies accepted. Data logging will begin immediately when changing the target website to capture transitional power draw.
         (1) Google.com
         (2) Yahoo.com
         (3) Live.com
         (4) Youtube.com
         (5) Facebook.com
         (6) Wikipedia.org
         (7) Ebay.com
         (8) Amazon.com
         (9) Craigslist.org
         (10) Bing.com

[3] The tested access speed exceeded 25 Mb/s.

    ii) Record all power, current, and voltage measurements in a database. Each test will take place for at least 6 minutes.
    iii) Move the mouse/trackpad once a minute to prevent the unit from going idle
  c) <u>Dynamic benchmark Test:</u> for each browser, the following three benchmarks will be run. Each will have a one minute transition time, before data logging begins.
      (1) HTML5 video "Big Buck Bunny" on YouTube
      (2) Flash® video of "Big Buck Bunny" on YouTube
      (3) The "FishBowl" benchmark, limiting the number of fish to 5
    ii) Record all power, current, and voltage measurements in a database. Each test will take place for at least 6 minutes.
    iii) Move the mouse/trackpad once a minute to prevent the unit from going idle
7. Raw data from each test will be saved in individual CSV files from the power meter, labeled and stored in a directory structure.

3 Results

3.1 Power Measurements

Figures 3-1 and 3-2 depict the average of all power draw measurements, while Tables 3-1 and 3-2 summarize the power draw measurements for notebook and desktop computers, respectively. The full test results can be found in Appendix A.

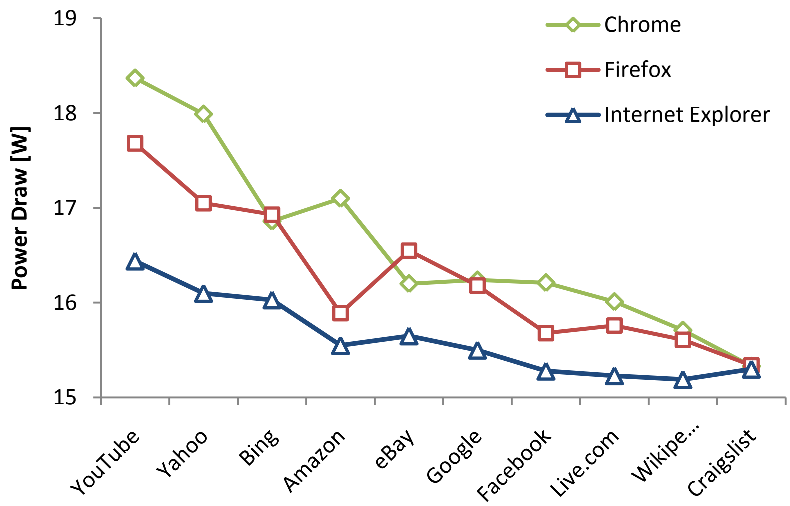

Figure 3-1: Average notebook computer power draw as a function of browser and website

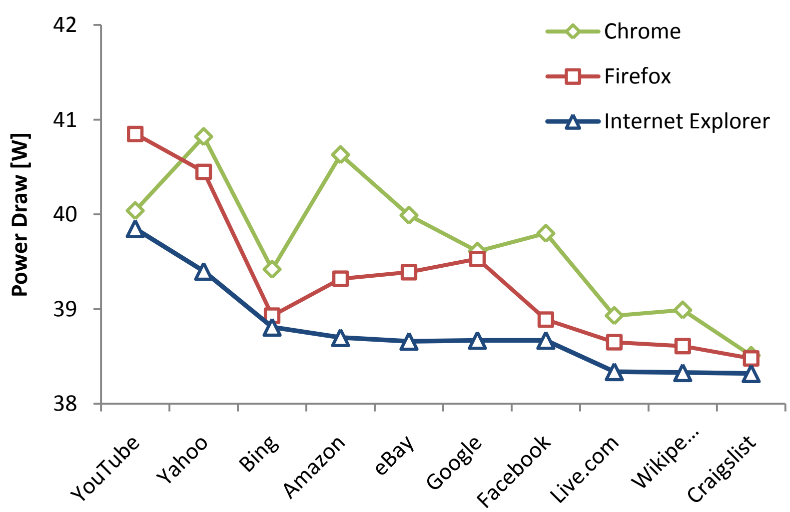

Figure 3-2: Average desktop computer power draw as a function of browser and website

Table 3-1: Notebook average power draw measurements summary (W)

	Baseline	Average, Top 10 Websites	Fish Bowl Benchmark	Big Buck Bunny - Flash	Big Buck Bunny – HTML5
Google Chrome	14.7	16.6	37.6	26.0	25.0
Microsoft Internet Explorer	14.7	15.6	34.9	21.2	22.0
Mozilla Firefox	14.7	16.3	32.0	23.4	24.9

Table 3-2: Desktop average power draw measurements summary (W)

	Baseline	Average, Top 10 Websites	Fish Bowl Benchmark	Big Buck Bunny - Flash	Big Buck Bunny – HTML5
Google Chrome	37.8	39.7	61.8	51.7	47.0
Microsoft Internet Explorer	37.8	38.8	53.9	48.2	44.0
Mozilla Firefox	37.8	39.3	53.9	50.0	49.0

3.2 UEC and AEC Impact of Internet Browsers

Tables 3-3 and 3-4 presents the *normalized* power draw values used to estimate the UEC and AEC impact of browsers for notebook and desktop computers, respectively. They are calculated per the normalization procedure described in Section 2.1.3.[4]

There are several important caveats to note about these estimates. First, these calculations are based on the assumption that the power draw ratios measured for a limited number of new computers would be similar for the installed base of residential PCs, including those with different operating systems. This project did not include the testing required to evaluate that assumption. Second, the Flash® power draw values are based on measurements for a single Flash® video, so it is not clear if those values are representative of a wider range of Flash® videos. Third, we did not evaluate the impact on power draw of setting the default Javascript time frequency for all computers to "maximum power saving".

Table 3-3: Normalized notebook power draw values for UEC and AEC calculations (W)

	Active, no browser	Browser. Top 10 Websites	Browser, Flash
Google Chrome	19	21.4	32.6
Microsoft Internet Explorer	19	20.2	26.5
Mozilla Firefox	19	21.0	29.5

[4] Since we used the averages of the power draw *ratios* of the test cases relative to the power draw for *each* computer, these ratios differ in some cases from power ratios calculated based on Tables 3-1 and 3-2.

Table 3-4: Normalized desktop power draw values for UEC and AEC calculations (W)

	Active, no browser	Browser, Top 10 Websites	Browser, Flash
Google Chrome	60	63.0	73.5
Microsoft Internet Explorer	60	61.6	68.3
Mozilla Firefox	60	62.5	70.9

Tables 3-5 and 3-6 present the UEC and AEC values for the Internet browsers tested, for notebook and desktop PCs, based on the power draw estimates above. All differences are relative to the baseline value assuming no browser operation. The models indicate that browsers increase both UEC and AEC by an average of approximately 1 to 3 percent relative to an "idle" baseline, with Chrome having the largest increase and Internet Explorer the smallest. The main uncertainties in these estimates are the power draw impact of Flash® and the quantity of time residential computers spend with browsers open, particularly on web pages running Flash® video.

Table 3-5: Impact of Internet browsers upon U.S. notebook computer UEC and AEC

	UEC Browser	UEC Flash	UEC Other Active	UEC Sleep & Off	UEC (kWh) Total	AEC (TWh)
Baseline	17.6	4.0	34	7.1	63	8.3
Google Chrome	19.9	6.9	34	7.1	68	8.9
Microsoft Internet Explorer	18.8	5.6	34	7.1	65	8.6
Mozilla Firefox	19.5	6.2	34	7.1	67	8.8

Table 3-6: Impact of Internet browsers upon U.S. desktop computer UEC (kWh) and AEC (TWh)

	UEC Browser	UEC Flash	UEC Other Active	UEC Sleep & Off	UEC (kWh) Total	AEC (TWh)
Baseline	55.6	12.6	137	15.0	220	22.2
Google Chrome	58.4	15.5	137	15.0	226	22.8
Microsoft Internet Explorer	57.1	14.4	137	15.0	223	22.6
Mozilla Firefox	57.9	14.9	137	15.0	225	22.7

4 Conclusions

We conducted controlled tests on six notebook and four desktop computers to evaluate the impact of three Internet browsers on computer power draw. Specifically, we measured the average power draw over one-second intervals for a six-minute period for all three browsers installed on the ten computers, for each of the ten most-visited websites in the U.S. In addition, we also measured power draw for both the Flash® and HTML5 versions of a video, as well as the Fishbowl HTML5 benchmark.

Our measurements show that the Internet browsers tested increased computer power draw by about 7 to 13 percent for notebooks and 3 to 5 percent for desktops, relative to an “idle” baseline (see Table 4-1 and 4-2). The magnitude of the *absolute* power draw increase was similar for notebooks and desktops. For the top ten U.S. websites tested, average computer power draw increased the most while using the Chrome browser and the least while using the Internet Explorer browser. Variations in power draw among websites tested were of a similar magnitude as differences in power draw among browsers.

Table 4-1: Notebook average power draw measurements summary (W)

	Baseline	Average, Top 10 Websites
Google Chrome	14.7	16.6
Microsoft Internet Explorer	14.7	15.6
Mozilla Firefox	14.7	16.3

Table 4-2: Desktop average power draw measurements summary (W)

	Baseline	Average, Top 10 Websites
Google Chrome	37.8	39.7
Microsoft Internet Explorer	37.8	38.8
Mozilla Firefox	37.8	39.3

Testing of two HTML5 websites (one benchmark, one video) and one Flash® video found that both appear to increase power draw significantly more than the top ten websites tested. Most notably, the HTML5 benchmark test condition more than doubled the notebook power draw for all computers and browsers tested, while desktop power draw increased by approximately 50 percent. Computer power draw also increased for the one Flash® and HTML5 website tested, increasing by approximately 50 and 20 percent for notebook and desktops, respectively. The magnitude of the *absolute* power draw increase was similar for notebooks and desktops. Due to the very limited number of test conditions, we cannot draw robust conclusions about differences in power draw among browsers running Flash® and HTML5. Conducting additional testing of a larger set of Flash® and HTML5 websites is necessary to draw more robust conclusions about how these technologies impact computer power draw, and we recommend pursuing this testing.

Incorporating the test data into models for residential computer unit electricity consumption (UEC) and national annual electricity consumption (AEC) indicates that the browsers tested increased both by an average of approximately 1 to 3 percent relative to an “idle” baseline. The largest uncertainties in these estimates are the power draw impact of Flash® and the quantity of time residential computers spend with browsers open, particularly on web pages running Flash® video.

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Appendix A: Test Data

Tables A-1 and A-2 present the desktop and notebook computer power draw measurements, respectively.

Table A-1: Desktop computer power draw measurements

		HP_TOUCHSMART	DELL_660S	DELL_XPS	HP_ENVY
Baseline		39.16	24.81	31.64	55.49
Google.com	Internet Explorer	39.54	25.11	32.88	57.15
	Chrome	39.80	25.86	33.19	59.59
	Firefox	40.56	25.84	32.71	59.00
Facebook.com	Internet Explorer	39.70	25.16	32.82	56.93
	Chrome	39.82	25.77	34.88	58.71
	Firefox	40.24	25.46	32.62	57.22
YouTube.com	Internet Explorer	40.29	28.29	33.80	57.00
	Chrome	40.33	26.94	34.69	58.21
	Firefox	41.11	30.85	34.12	57.32
Yahoo.com	Internet Explorer	40.21	25.48	33.66	58.26
	Chrome	40.73	26.91	34.58	61.04
	Firefox	41.04	26.34	33.68	60.73
Amazon.com	Internet Explorer	39.94	25.19	32.52	57.14
	Chrome	40.23	27.01	34.06	61.21
	Firefox	39.94	25.41	32.71	59.23
eBay.com	Internet Explorer	39.77	25.31	32.77	56.80
	Chrome	40.11	26.31	33.36	60.16
	Firefox	40.34	25.66	33.09	58.45
Wikipedia.com	Internet Explorer	39.45	25.36	31.97	56.52
	Chrome	39.45	25.60	32.66	58.23
	Firefox	39.77	25.26	32.54	56.88
Craigslist.org	Internet Explorer	39.50	25.12	31.97	56.67
	Chrome	39.41	25.47	32.30	56.84
	Firefox	39.77	25.01	32.25	56.90
Live.com	Internet Explorer	39.55	25.07	32.28	56.47
	Chrome	39.49	25.62	32.90	57.71
	Firefox	39.77	25.28	32.34	57.20
Bing.com	Internet Explorer	40.14	25.27	32.79	57.04
	Chrome	40.18	26.12	33.00	58.37
	Firefox	40.35	26.05	32.47	56.83

Table A-2: Notebook computer power draw measurements

		Lenovo_ideapad	HP_G7	TOSHIBA	DELL_INSP	SAMSUNG	ASUS
Baseline		22.65	14.18	13.44	16.68	11.73	9.76
Google.com	Internet Explorer	23.03	15.01	13.77	18.11	12.93	10.14
	Chrome	24.84	15.77	13.99	19.61	12.56	10.65
	Firefox	25.15	15.82	13.83	18.19	13.17	10.91
Facebook.com	Internet Explorer	22.73	14.84	13.60	17.87	12.63	10.02
	Chrome	24.79	15.46	13.88	19.82	12.57	10.76
	Firefox	24.40	15.54	13.70	17.85	12.36	10.25
YouTube.com	Internet Explorer	23.06	15.03	16.25	19.74	12.40	12.14
	Chrome	25.99	15.27	18.60	23.60	12.37	14.36
	Firefox	24.53	15.40	17.65	22.24	12.42	13.86
Yahoo.com	Internet Explorer	23.50	15.65	14.37	19.27	13.19	10.61
	Chrome	29.11	17.29	15.12	19.86	14.72	11.81
	Firefox	25.40	16.97	15.20	19.24	13.94	11.53
Amazon.com	Internet Explorer	22.96	14.86	13.61	17.93	13.62	10.31
	Chrome	25.93	16.83	14.88	19.80	13.67	11.48
	Firefox	24.14	15.50	13.93	18.24	13.16	10.35
eBay.com	Internet Explorer	23.02	15.48	14.17	18.01	12.84	10.39
	Chrome	25.42	15.64	13.69	18.81	12.65	10.99
	Firefox	24.38	15.92	14.00	20.73	12.96	11.33
Wikipedia.com	Internet Explorer	22.79	14.83	13.74	17.35	12.24	10.17
	Chrome	24.60	15.02	13.81	17.90	12.35	10.59
	Firefox	24.19	15.42	13.85	17.62	12.25	10.35
Craigslist.org	Internet Explorer	22.91	14.86	13.68	17.31	13.03	10.01
	Chrome	23.71	14.65	13.53	17.34	12.25	10.51
	Firefox	24.00	15.17	13.52	17.20	12.09	10.08
Live.com	Internet Explorer	22.98	14.81	13.57	17.39	12.46	10.15
	Chrome	24.64	15.12	13.71	17.89	14.06	10.62
	Firefox	24.06	15.36	13.81	18.54	12.46	10.34
Bing.com	Internet Explorer	23.92	15.47	13.64	18.14	14.64	10.37
	Chrome	24.42	15.64	14.12	19.22	16.79	10.97
	Firefox	24.87	15.95	13.93	18.64	17.75	10.46